Search for Neutron Deficient Plutonium Isotopes: Development of a Fast and Sensitive Separation Technique

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The half-life of the highly neutron-deficient Pu-isotopes, ^{228,229}Pu and ^{231}Pu, identified by Andreyev et al.[1,2], can be estimated based on α-decay and Q-value systematic. The expected half-lives of ^{229}Pu and ^{230}Pu are in the range of 10 to 60 seconds and that of ^{231}Pu is on the order of a few minutes.

These isotopes were produced by irradiation[3] of ^{233}U targets with ^{3}He beams and delivered to the chemistry laboratory with a He/KCl aerosol gas-jet. Together with the Pu isotopes produced via xn-reactions, large quantities of Np-, U-, Pa-, and Th-isotopes were produced via xpxn-, αxn- and αxpxn-reactions. The decay chains from these other isotopes interfere strongly with the identification of the decay chains of the Pu isotopes, so the development of a fast and selective Pu chemical separation was necessary.

In a first attempt, the extraction system 0.2 mol/L TTA in toluene with 0.5 mol/L nitric acid was used. TTA was chosen due to its ability to separate metal ions in different valence states[4]. The activities in the collected aerosols were dissolved in nitric acid; Pu should be in the (IV) oxidation state. The chemical yield for Pu was 40%, but as the data show, Th and Pa were also extracted to a considerable extent, making identification of the Pu isotopes difficult. The decay chains of the directly produced Pu daughters tend to obscure the Pu decay chains themselves. The cross section for ^{232}Pu as shown in ref. 3 could not be determined at projectile energies of 60 and 72 MeV due to the large amounts of directly produced ^{228}U.

A second chemical separation technique was based on known anion exchange techniques[5,6]. The KCl aerosols, containing the collected reaction products, were dissolved in 9 mol/L HCl and transferred to a column filled with Dowex 1x8 anion exchange resin. Th^{4+} and all trivalent ions were eluted immediately with 9 mol/L HCl. Pu^{4+} was reduced to Pu^{3+} and eluted using a mixture of conc. HCl and conc. HI, leaving Np, U and Pa adsorbed on the column. Since ^{230}U, ^{229}U, ^{231}Np and ^{227}Pa are also produced this reaction and are adsorbed onto the used resin under the describe conditions, too, their daughters, Th and Ac isotopes, will elute within the Pu fraction. These isotopes provide because of similar α-decay energies such interference, that an identification of the short lived Pu isotopes is very difficult.

Some evidence for the production of ^{231}Pu at 30 to 40 MeV ^{3}He projectile energy and for ^{230}Pu at 55 to 60 MeV ^{3}He projectile energy could be seen, but for an unequivocal identification a better chemical separation has to be established.

Footnotes and References

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5. G.H.Coleman, NAS-NS 3058 (1965)
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